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Two new species of black flies (Diptera: Simuliidae) from northern Thailand

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Abstract: Two new species of black flies, i.e., *Simulium* (*Simulium*) *lampangense* sp. nov. and *S.* (*S.*) *yuphae* sp. nov., are described based on specimens collected in northern Thailand. *Simulium* (*S.*) *lampangense* sp. nov. is assigned to the *multistriatum* species-group, and is distinguished from all the other members by the diverged gill filaments combined with the fenestrated cocoon in the pupal stage, and *S.* (*S.*) *yuphae* sp. nov., a member of the *tuberosum* species-group, is very similar to *S.* (*S.*) *brevipar* Takaoka and Davies, but is distinguished by the configuration of the six pupal gill filaments, of which one of the ventral paired filaments always runs posteriorly or ventrally.

Key words: black fly, *Simulium*, Simuliidae, Thailand, new species

During recent surveys on aquatic stages of black flies in Thailand, we collected 14 new species of the subgenus *Simulium* (*Simulium*) Latreille s. str., of which 12 species were already described (Takaoka, 2001, Takaoka and Choochote, 2002, 2004 a,b, 2005a,b,c,d,e). In this paper, we describe two remaining new species, of which one is very similar to *S.* (*S.*) *fenestratum* Edwards, and the other to *S.* (*S.*) *brevipar* Takaoka and Davies.

The terms for morphological features used here follow those of Takaoka (2003). Holotype and paratype specimens of the new species are deposited at the Department of Infectious Disease Control, Faculty of Medicine, Oita University, Oita, Japan.

Simulium (*Simulium*) *lampangense* sp. nov.

DESCRIPTION. **Female**. Body length 2.1–2.6 mm. ***Head***. Narrower than thorax. Frons brownish-black, shiny, with several dark stout hairs along lateral margins; frontal ratio 1.27–1.34 : 1.00 : 1.33–1.46; frons-head ratio 1.0 : 3.9–4.1. Fronto-ocular area (Fig. 1A) well developed, short, directed laterally. Clypeus brownish-black, white pruinose, shiny, moderately covered with dark stout hairs except upper 1/2 widely bare medially. Labrum 0.65–0.71 times as long as clypeus. Antenna composed of 2+9 segments, yellow on scape, pedicel, and 1st to 3 rd flagellar segments, and medium brown on rest of flagella in front view; antenna medium brown except scape, pedicel, and base of 1st flagellar segment yellow in posterior view. Maxillary palp with 5 segments, light to dark brown, proportional lengths of 3rd, 4th, and 5 th segments 1.0 : 1.1–1.2 : 2.2–2.4; 3rd segment (Fig. 1B) of normal size, with large oblong sensory vesicle (0.44 times as long as 3rd segment) having medium-sized opening apically. Maxillary lacinia with 12 or 13 inner and 12 or 13 outer teeth. Mandible with ca. 24 inner and 10–12 outer teeth. Cibarium (Fig. 1C) with blunt median projection on posterior margin and without any minute processes near base of

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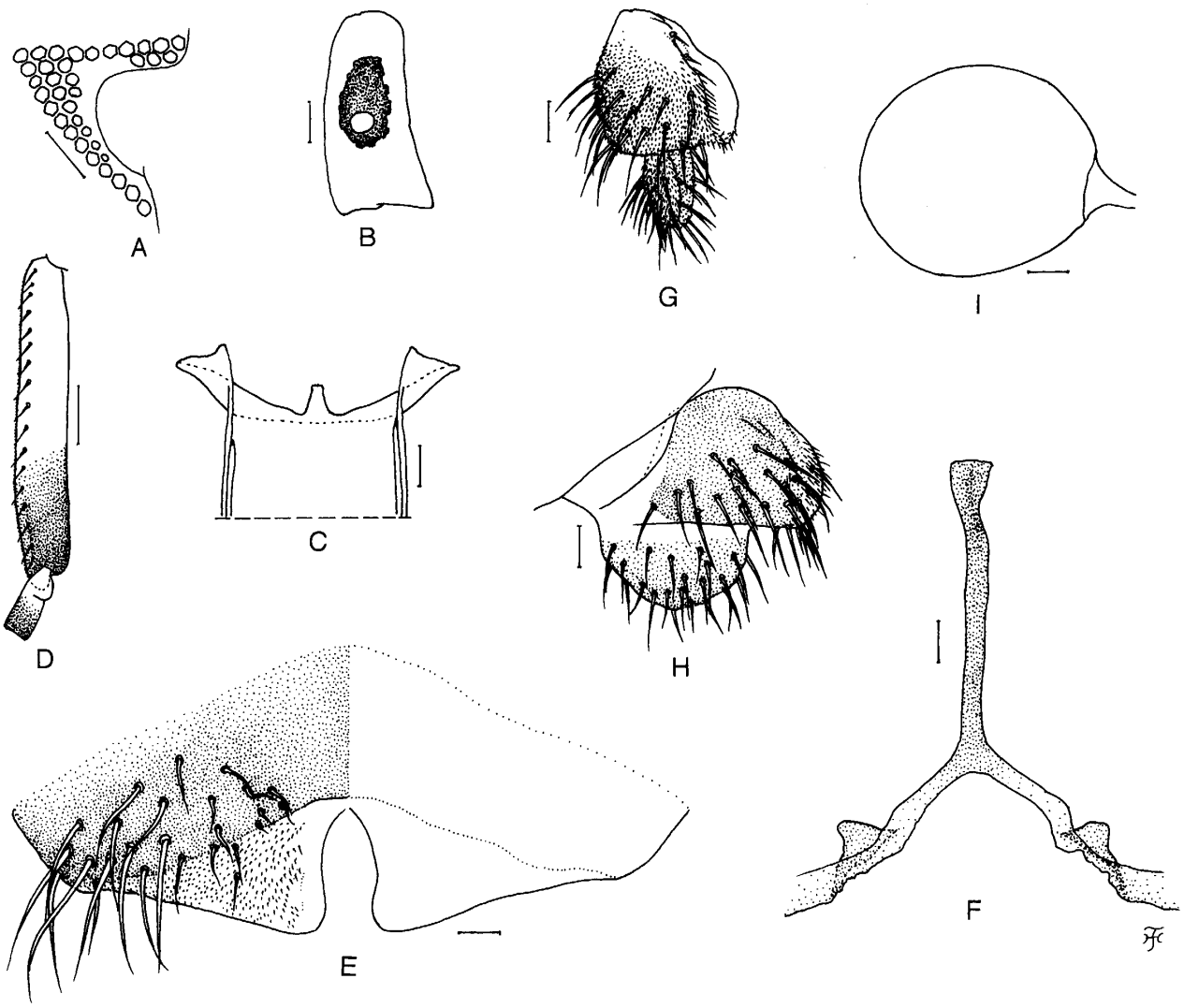

Fig. 1. Adult female of *Simulium* (*Simulium*) *lampangense* sp. nov. A, fronto-ocular area; B, 3rd segment of maxillary palp showing sensory vesicle (right side, front view); C, cibarium; D, basitarsus and 2nd tarsal segment of hind leg (left side, outer view); E, 8th sternite and ovipositor valves *in situ* (ventral view); F, genital fork (ventral view); G and H, paraprocts and cerci (right side; G, ventral view; H, outer view); I, spermatheca. Scale bars. 0.1 mm for D; 0.05 mm for A; 0.02 mm for B, C and E–I.

median projection. ***Thorax***. Scutum dark brown to brownish-black, shiny, densely covered with whitish-yellow recumbent short hairs interspersed with several dark long upright hairs on prescutellar area; when illuminated in front and viewed dorsally, scutum thickly white pruinose, with 5 longitudinal unpruinose vittae, of which 1 median vitta is of moderate width, 2 submedian and 2 sublateral vittae rather wide (though sublateral vittae somewhat wider than submedian ones), all vittae united with broad transverse band on prescutellar area; when illuminated from behind, scutum having reversed color pattern. Scutellum medium to dark brown, covered with dark upright long hairs as well as whitish-yellow short hairs. Postnotum dark brown to brownish-black, shiny, grey pruinose, bare. Pleural membrane bare. Katepisternum longer than deep, bare. ***Legs***. Foreleg: coxa and trochanter yellowish-white; femur yellow on basal 1/2 or a little less, light to medium brown on rest on outer surface; femur yellow extensively on inner surface except apical cap light to medium brown; tibia white except apical cap brownish-black; tarsus brownish-black, with moderate dorsal hair crest; basitarsus greatly dilated, 4.7 times as long as its greatest width. Midleg: coxa brownish-black; trochanter light brown except base yellow; femur light to medium brown with apical cap dark brown (though basal portion yellowish in

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some females); tibia white to yellowish-white except apical cap medium to dark brown; tarsus medium to dark brown except basal 1/2–3/5 of basitarsus yellowish-white. Hind leg: coxa dark brown; trochanter yellow; femur light to medium brown except basal 3/10 yellow and apical cap dark brown; tibia white to yellowish-white on basal 3/4 or a little less, dark brown to brownish-black on rest; tarsus blackish-brown except basal 3/5 of basitarsus, and a little less than basal 1/2 of 2nd segment yellowish-white; basitarsus (Fig. 1D) nearly parallel-sided, 6.1 times as long as wide, and 0.70 and 0.58 times as wide as greatest widths of hind tibia and femur, respectively; calcipala (Fig. 1D) moderately developed, slightly shorter than its width, not reaching level of pedisulcus, and 0.42 times as wide as greatest width of basitarsus; pedisulcus (Fig. 1D) well developed at basal 1/3 of 2nd tarsal segment. All tarsal claws simple. ***Wing***. Length 2.0–2.2 mm. Costa with dark spinules and hairs; subcosta haired except near apex bare; basal section of radial vein bare; R_1 with dark spinules and hairs; R_2 with hairs; hair tuft on stem vein dark brown; basal cell absent. ***Abdomen***. Basal scale light yellow to light brown, with fringe of pale hairs. Dorsal surface of abdomen dark brown to brownish-black except basal 1/2–3/5 of 2nd segment yellowish-white, with short dark hairs; tergite 2 shiny, white iridescent when illuminated, and tergites 6–8 shiny. Ventral surface of 7th segment with large weakly sclerotized sternal plate medially. ***Genitalia***. Sternite 8 (Fig. 1E) with 25–28 dark medium-long to long stout hairs on each lateral surface. Ovipositor valves (Fig. 1E) triangular, rounded posteromedially, widely separated from each other, membranous, moderately covered with microsetae and 1 or 2 pale or dark medium-long hairs, except portion along inner margin widely bare, and so thin and transparent that it is difficult to discern inner margins. Genital fork (Fig. 1F) of inverted-Y form, with narrow well sclerotized stem; arms of moderate width, each with distinct projection directed anterodorsally. Paraproct (Fig. 1G, H) strongly sclerotized on outer surface but unsclerotized on anterior and inner surfaces, moderately protruding ventrally beyond cercus, with numerous stout hairs on lateral and ventral surfaces, and with 3 or 4 short sensilla on inner surface. Cercus (Fig. 1G, H) short, about half as long as wide, with numerous stout hairs, and rounded posteriorly when viewed laterally. Spermatheca (Fig. 1I) nearly ovoid, well sclerotized except small portion of juncture to duct unsclerotized, with weakly defined reticulate patterns on its surface, and with internal setae; accessory ducts subequal in thickness to each other, and subequal to, or slightly thicker than, major duct.

Male. Body length 2.4–2.6 mm. ***Head***. Width subequal to that of thorax. Upper eye consisting of large facets in 18 or 19 horizontal rows and in 17 or 18 vertical columns. Clypeus brownish-black, thickly white pruinose, covered with dark brown hairs along and near lateral margins (most of central portion bare). Antenna composed of 2+9 segments, medium to dark brown except scape, pedicel, and base of 1st flagellar segment yellow; 1st flagellar segment elongate, 1.8–1.9 times as long as 2nd one. Maxillary palp dark brown, composed of 5 segments with proportional lengths of 3rd, 4th, and 5th segments 1.0 : 1.3–1.4 : 2.7; 3rd segment (Fig. 2A) of normal size; sensory vesicle small (0.21–0.24 times as long as 3rd segment), globular or ellipsoidal, and with small or very small opening apically. ***Thorax***. Scutum brownish-black, with white pruinose pattern, i.e., anterior pair of rectangular spots on shoulders extending posteriorly along lateral margins and connected to large transverse spot entirely covering prescutellar area; these pruinose areas silvery iridescent when illuminated at certain angles of light; scutum uniformly and densely covered with golden-yellow recumbent short hairs interspersed with dark brown long upright hairs on prescutellar area. Scutellum dark brown, shiny, white pruinose, with several dark long upright hairs as well as golden-yellow short hairs. Postnotum, pleural membrane and katepisternum as in female. ***Legs***. Foreleg: coxa whitish-yellow; trochanter light brown though most of inner surface yellowish; femur light brown basally, gradually darkened toward apex, and with apical cap medium brown, though anteroinner surface yellowish on a little less than basal 1/2 and light brown on rest; tibia medium brown to brownish-black except outer surface of basal 4/5 white, and with large white sheen when illuminated; tarsus brownish-black, with moderate dorsal hair crest; basitarsus moderately dilated, 5.5–5.6 times as long as its greatest width. Midleg: coxa dark brown with posterior surface brownish-black; trochanter medium

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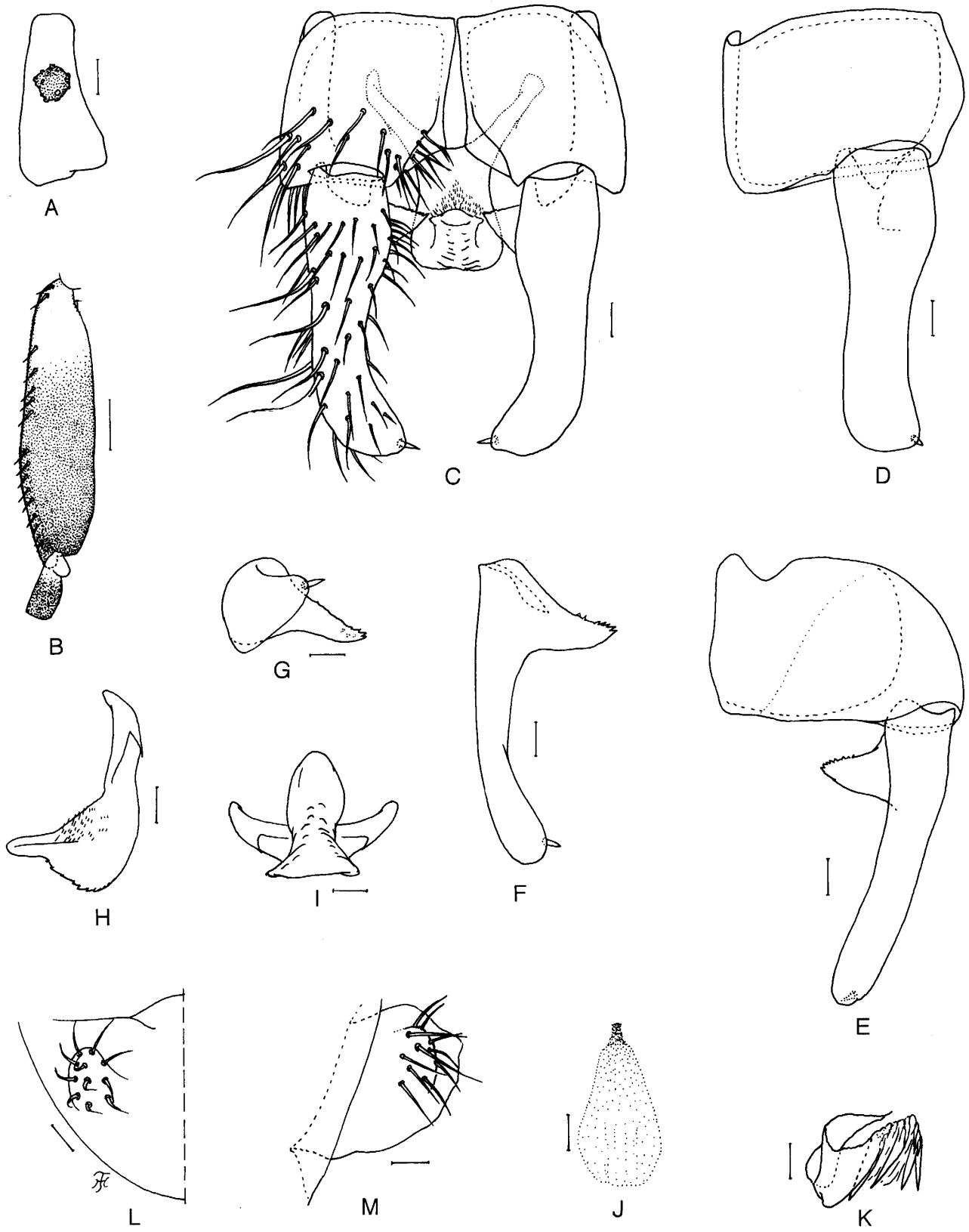

Fig. 2. Adult male of *Simulium* (*Simulium*) *lampangense* sp. nov. A, 3rd segment of maxillary palp with sensory vesicle (right side, front view); B, basitarsus and 2nd tarsal segment of hind leg (left side, outer view); C, coxites, styles and ventral plate *in situ* (ventral view); D and E, coxites and styles on right side (D, ventrolateral view; E, outer view); F and G, right styles with basal protuberance (F, medial view; G, end view); H and I, ventral plates (H, lateral view; I, end view); J, median sclerite (end view); K, paramere (right side, end view); L and M, 10th abdominal segments with cercus on right side (L, end view; M, outer view). Scale bars. 0.1 mm for B; 0.02 mm for A and C–M.

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brown except basal 1/2 yellowish; femur medium brown; tibia white to yellowish-white on basal 2/5, then gradually darkened from dark yellow or light brown to dark brown toward apex, and with white sheen on posterior surface of basal 1/2 or a little less when illuminated; tarsus dark brown except basal 1/2 or a little less of basitarsus yellowish. Hind leg: coxa dark brown; trochanter yellow; femur medium to dark brown except base yellow and apical cap brownish-black; tibia dark brown to brownish-black except base whitish-yellow; tarsus dark brown to brownish-black except basal 1/3 or a little less of basitarsus and basal 1/3 of 2nd segment dark yellow; basitarsus (Fig. 2B) much enlarged, spindle-shaped, about 3.7 times as long as its greatest width, and 0.92 and 0.99 times as wide as greatest widths of hind tibia and femur, respectively; calcipala small, nearly as long as, or slightly shorter than, its width; pedisulcus well marked. ***Wing***. Length about 2.0 mm; other characters as in female except subcosta with 0–4 hairs. ***Abdomen***. Basal scale brownish-black, with fringe of dark long hairs. Dorsal surface of abdomen dark brown to brownish-black except basal 2/3 of 2nd segement light to medium brown, with dark short hairs; segments 2, and 5–7 each with pair of silvery iridescent spots dorsolaterally, those on segment 2 connected broadly to each other in middle; ventral surface of abdomen pale except tergal plates medium to dark brown. ***Genitalia***. Coxite in ventral view (Fig. 2C) nearly quadrate and in ventrolateral view (Fig. 2D) 1.5 times as wide as long, and 0.53 times as long as style. Style in ventral view (Fig. 2C) elongate, nearly parallel-sided from base to basal 1/3, then narrowed toward basal 2/3, and slightly widened apically, with apical spine; style in ventrolateral view (Fig. 2D) elongate, about 3.1 times as long as its greatest width near base, with inner margin slightly sinuous, nearly parallel-sided from base to basal 1/3, narrowed to a little beyond midpoint, then nearly parallel-sided or slightly widened toward apex; style in lateral view (Fig. 2E) spatulate dorsoventrally; style in medial and end views (Fig. 2F, G) with long pointed protuberance basally on dorsal surface, bearing several small spinules on its anterior surface and at apex. Ventral plate in ventral view (Fig. 2C) with base nearly rectangular (though somewhat narrowed basally, and rounded on each posterolateral corner), sparsely covered with setae medially; arms directed forward and outward diverging from each other at right angle; ventral plate in lateral view (Fig. 2H) with distinct serrated posterior margin; ventral plate in end view (Fig. 2I) having 2 vertical rows of 5–10 teeth on posterior surface of base, and with elliptical bare process (though sparsely setose on anterior surface) protruding ventrally. Median sclerite (Fig. 2J) plate-like, widening from base toward near apex, with round apex; median sclerite brown basally, but not so well sclerotized posteriorly. Paramere (Fig. 2K) with 4 distinct hooks. Aedeagal membrane moderately covered with minute setae, and with no sclerotized dorsal plate. Abdominal segment 10 (Fig. 2L, M) without any distinct hair on ventral and lateral surfaces. Cercus (Fig. 2L, M) small, rounded, with 9–11 distinct hairs.

Pupa. Body length 2.5–2.8 mm. ***Head***. Integument including antennal sheaths yellow to dark yellow, densely and elaborately covered with round tubercles; frons with 2 pairs of simple slender short and medium-long trichomes (Fig. 3A) (in 1 pupa, additional short trichome present on left side); face with pair of simple long trichomes (Fig. 3B) nearly twice as long as medium-long trichome on frons; ***Thorax***. Integument yellow to dark yellow, densely and elaborately covered with small round tubercles; thorax on each side with 3 long stout trichomes each with 0–4 branches (Fig. 3C, D) anterodorsally, 2 simple and/or bifid long stout trichomes (similar in size and shape to those on anterodorsal surface) anterolaterally, 1 medium-long simple stout trichome (Fig. 3E) posterolaterally, and 2 simple long stout trichomes and 1 simple or bifid medium-long slender trichome (Fig. 3F, G) ventrolaterally. Gill (Fig. 3H) with 8 short slender thread-like filaments in 4 pairs (1 dorsal, 2 middle and 1 ventral) arising from very short common basal stalk; all pairs short-stalked (though 1 pupa having elongated stalks of ventral pair, each 0.3 mm long on right side and 0.6 mm long on left side), and stalks of dorsal and ventral pairs widely diverged forming an obtuse angle of 140–180 degrees when viewed laterally; all filaments subequal in length to one another (1.3–1.7 mm long) except lower filament of ventral pair always shorter than others (1.0–1.2 mm long), and variable in thickness when basal portions were compared, i.e., 2 filaments of dorsal pair (though upper filament

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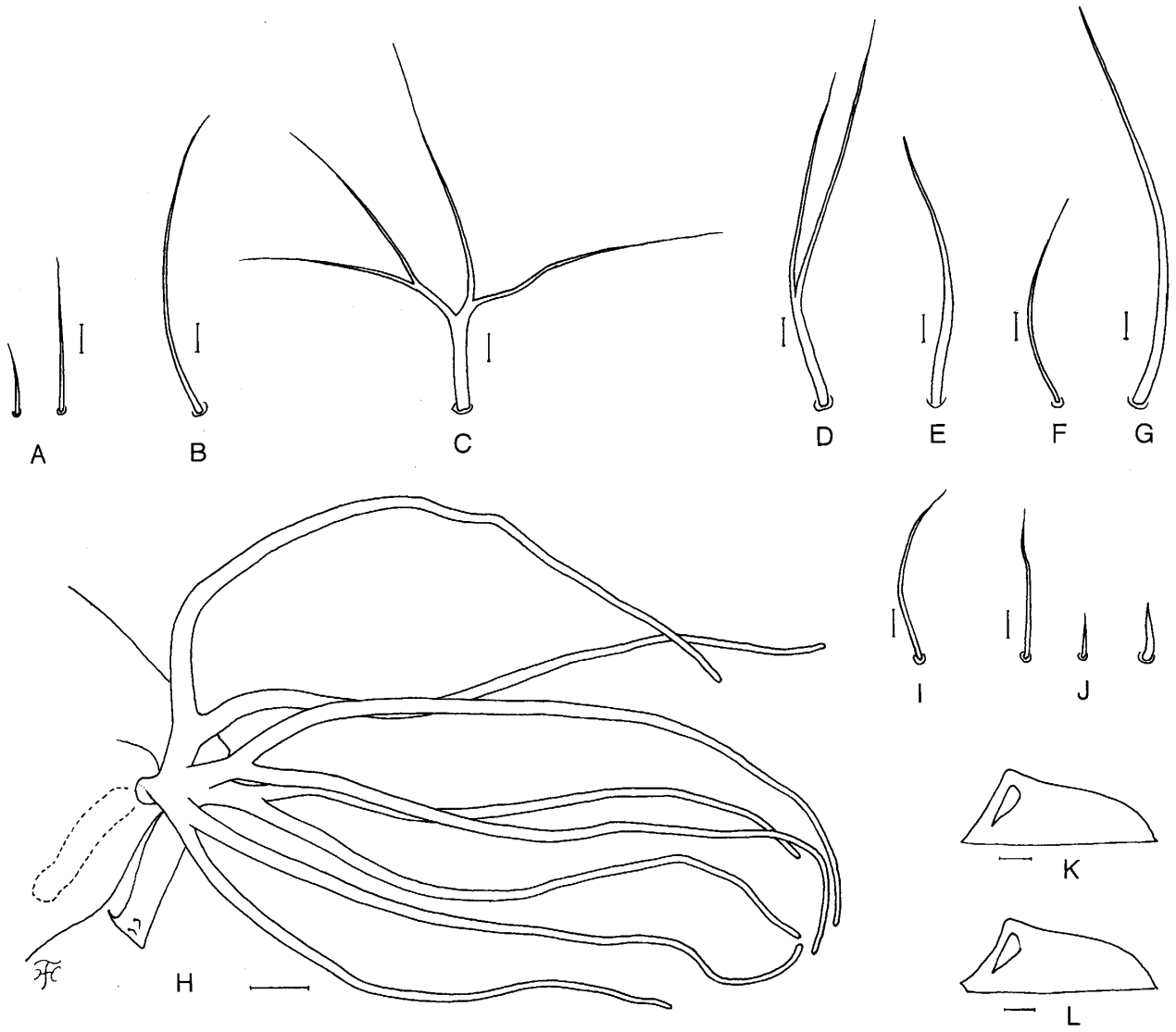

Fig. 3. Pupa of *Simulium* (*Simulium*) *lampangense* sp. nov. A, frontal trichomes; B, facial trichome; C–G, trichomes on thorax (C and D, mediodorsal; E, posterolateral; F and G, ventrolateral); H, gill filaments (right side, outer view); I, hair-like seta on dorsal surface of abdominal segment 1; J, hair-like seta and short spines of different sizes on dorsal surface of abdominal segment 2; K and L, cocoons in lateral view (K, wall-pocket-shaped; L, shoe-shaped). Scale bars. 0.5 mm for K and L; 0.1 mm for H; 0.01 mm for A–G, I and J.

subequal to, or slightly thicker than, its counter filament) thickest of all, lower filament of ventral pair thinnest, 0.46–0.53 times as thick as dorsal paired filaments, and other filaments subequal in thickness to one another, or upper filaments of middle pairs slightly thicker than both their counter filaments and upper filament of lower pair; all filaments light yellow to light yellowish-brown, tapered toward apex, with distinct annular ridges and furrows forming definite reticulate surface patterns, and densely covered with minute tubercles of different sizes (larger ones on ridges and smaller ones on interridge spaces). ***Abdomen***. Dorsally, segment 1 weakly sclerotized, light ocherous, with 1 medium-long simple slender seta (Fig. 3I) on each side; segment 2 transparent, bare, with 1 medium-long simple slender seta, 1 or 2 short simple setae and 3 or 4 short stout spines (Fig. 5J) on each side; segments 3 and 4 transparent, each with 4 distinct simple hooks and 1 short simple seta on each side; segments 5 and 6 transparent, lacking spine-combs; segments 7–9 each with distinct spine-combs in transverse row (though those on segment 9 usually much smaller than those on segment 8), and also comb-like groups of minute spines on each side; segment 9 without terminal hooks. Ven-

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trally, segments 3–8 transparent, each with comb-like groups of minute spines; segment 4 with a few slender minute setae on each side; segment 5 with pair of bifid stout hooks submedially and a few simple short setae on each side; segments 6 and 7 each with pair of bifid inner and simple outer stout hooks somewhat separated from each other, and a few simple short setae on each side. Grapnel- like hooklets absent on each side of segment 9. ***Cocoon*** (Fig. 3K, L). Wall-pocket-shaped or shoe-shaped with very low anterior collar, thinly to moderately woven except anterior margin thickly woven, with anterolateral window(s) on each side (though anterolateral open spaces were too small, then not so distinct in a few cocoons), not extending ventrolaterally; individual threads visible or invisible; light yellow to dark brown; 3.0–3.5 mm long by 1.1–1.4 mm wide.

Mature larva. Unknown.

TYPE SPECIMENS. Holotype female with its associated pupal exuvia and cocoon, collected at Wang Kaew Waterfall, Amphur Wang Nuea, Lampang province, northern Thailand, 15.VI.2001, by H. Takaoka and W. Choochote. Paratypes: 10 females, 10 males, each with its associated pupal exuviae and cocoon, same data and date as those of the holotype.

ECOLOGICAL NOTES. The pupae of *S.* (*S.*) *lampangense* sp. nov. were collected from fallen tree leaves in a cascading stream (width 5–10 m, streambed rock, shaded, water temperature 23.5℃, altitude 570 m). Most of the pupae and their cocoons of this species, as well as stones in the streambed and submerged trailing grasses, were covered with a thick layer of calcareous sediments.

Associated species was *S.* (*S.*) *rudnicki* Takaoka and Davies and *S.* (*S.*) *weji* Takaoka.

ETYMOLOGY. The specific name *lampangense* refers to the name of the province, Lampang, where this new species was collected.

REMARKS. According to the keys (Takaoka, 2003), *S.* (*S.*) *lampangense* sp. nov. is assigned to the *multistriatum* species-group of the subgenus *Simulium* s. str. by having the scutum with five longitudinal vittae, simple claws in the female, the style with long basal protuberance (Fig. 2F, G), the ventral plate with toothed posterior margin (Fig. 2H, I) in the male, and the gill with eight filaments (Fig. 3H) in the pupa.

This new species is distinguished from all the seven known Thai species of this species-group by the combination of the two pupal characters, i.e., divergent gill filaments (Fig. 3H) and fenestrated cocoon (Fig. 3K, L). *Simulium* (*S.*) *fenestratum* Edwards, originally described from Sumatra (Edwards, 1934) and recorded from Thailand (Takaoka and Saito, 1996), has the cocoon with an anterolateral window but the gill is not diverged; *S.* (*S.*) *chaliowae* Takaoka and Boonkemtong, *S.* (*S.*) *triglobus* Takaoka and Kuvangkadilok, and *S.* (*S.*) *takense* Takaoka and Choochote have the diverged gill filaments but their cocoons are shoe-shaped with a moderately high anteroventral collar (Takaoka and Kuvangkadilok, 1999; Takaoka and Choochote, 2005c); *S.* (*S.*) *malayense* Takaoka and Davies and *S.* (*S.*) *chainarongi* Kuvangkadilok and Takaoka have the gill filaments not so diverged and the cocoon wall-pocket- or shoe-shaped without any window (Takaoka and Davies, 1995; Takaoka and Kuvangkadilok, 1999); and *S.* (*S.*) *bullatum* Takaoka and Choochote has the gill filaments not so diverged and is distinct by having a very large bulbous organ at the base of the pupal gill, which is absent in this new species, as in all the other known species of this species-group (Takaoka and Choochote, 2005a).

The female of this new species is very similar to those of all the seven known species in Thailand, and seems to be indistinguishable from one another although there are some differences in the following features (characters of *S.* (*S.*) *lampangense* in parentheses): basal portion of the radial vein of *S.* (*S.*) *fenestratum* is haired (bare);

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paraprocts of *S.* (*S.*) *chaliowae*, *S.* (*S.*) *chainarongi* and *S.* (*S.*) *triglobus* protrude much more ventrally, with their ratio of width/length 1.7–2.0 (1.3); cibarium of *S.* (*S.*) *bullatum* is sparsely covered with very minute processes near the base of median projection (bare); ovipositor valves of *S.* (*S.*) *takense* have a narrow bare portion along their inner margins (wide bare portion); the sensory vesicle of *S.* (*S.*) *malayense* is 0.3 times as long as the 3rd maxillary palpal segment (0.44 times).

On the other hand, the male of this new species is distinguished from those of the four known species (males of the other three known species are unknown yet) by the following features (characters of *S.* (*S.*) *lampangense* in parentheses): basal projection of the style of *S.* (*S.*) *fenestratum* has one apical spine (several spines); hind basitarsus of *S.* (*S.*) *chaliowae* entirely darkened (dark yellow on basal 1/3); styles of *S.* (*S.*) *chainarongi* and *S.* (*S.*) *takense* are rather broad throughout their length (much narrowed on apical 2/3).

All the 10 other members of the *multistriatum* species-group reported elsewhere (five from India, two from Tajikistan, one from Peninsular Malaysia, one from China and one from the Ryukyu Islands)(Crosskey and Howard, 1997) differ from this new species by having the pupal gill filaments not widely diverged (the angle formed by stalks of the dorsal and ventral pairs is approximately a right angle).

Simulium (*Simulium*) *yuphae* sp. nov.

Simulium (*Simulium*) *brevipar* (*nec* Takaoka and Davies, 1995): Takaoka and Saito, 1996: 168.

DESCRIPTION. **Female**. Body length 2.0–2.6 mm. ***Head***. Narrower than width of thorax. Frons brownish-black to black, shiny, with several dark stout hairs along lateral margins; frontal ratio 1.33–1.37 : 1.00 : 1.41–1.54; frons-head ratio 1.0 : 3.7–3.9. Fronto-ocular area (Fig. 4A) moderately developed, with round lateral tip. Clypeus brownish-black to black, shiny, with scattered dark stout hairs marginally (widely bare medially). Labrum 0.57–0.65 times as long as clypeus. Antenna composed of 2+9 segments, dark brown to brownish-black except scape, pedicel and basal 1/2 or more of 1st flagellar segment yellow in dorsal (or posterior) view (1st flagellar segment entirely yellow in ventral or anterior view). Maxillary palp medium brown to brownish-black, composed of 5 segments with proportional lengths of 3rd, 4th, and 5th segments 1.0 : 1.2 : 2.6; 3rd segment (Fig. 4B) of moderate size; sensory vesicle medium in size, elliptical, with rugged surface, 0.26–0.33 times as long as 3rd segment, with medium-sized round opening. Maxillary lacinia with 15 or 16 inner and 16–18 outer teeth. Mandible with 25 or 26 inner and 10 or 11 outer teeth. Cibarium (Fig. 4C) with numerous minute tubercles. ***Thorax***. Scutum brownish-black to black, shiny, not patterned, moderately covered with dark brown recumbent short hairs interspersed with dark long upstanding hairs on prescutellar area; scutum thinly grey pruinose when illuminated at certain angle of light. Scutellum brownish-black, with long dark hairs. Postnotum brownish-black, shiny, without hairs. Pleural membrane bare. Katepisternum longer than deep, and bare. ***Legs***. Foreleg: coxa and trochanter whitish-yellow; femur medium brown except base yellow; tibia medium brown to brownish-black with outer portion (except apical tip) largely pale white and white sheeny when illuminated; tarsus brownish-black to black, with thick dorsal hair crest; basitarsus much dilated, 3.9–4.3 times as long as its greatest width. Midleg: coxa brownish-black; trochanter dark brown; femur dark brown to brownish-black; tibia dark brown to brownish-black except base narrowly whitish-yellow and a little less than basal 1/2 of posterior surface yellowish-white; tibia white sheeny on posterior surface along basal 1/2 or a little more of shaft when illuminated; basitarsus whitish-yellow except apical tip medium brown; rest of tarsal segment medium brown except basal 1/2 to 2/3 of 2nd segment whitish-yellow. Hind leg: coxa brownish-black; trochanter yellow; femur dark brown with apical cap brownish-black and minute base yellow; tibia brownish-black with minute base whitish-yellow and basal 2/5 of posterior surface yellowish-white; tibia white sheeny on posterior surface along basal 1/2 or a little more of shaft when illuminated; tarsus medium to dark

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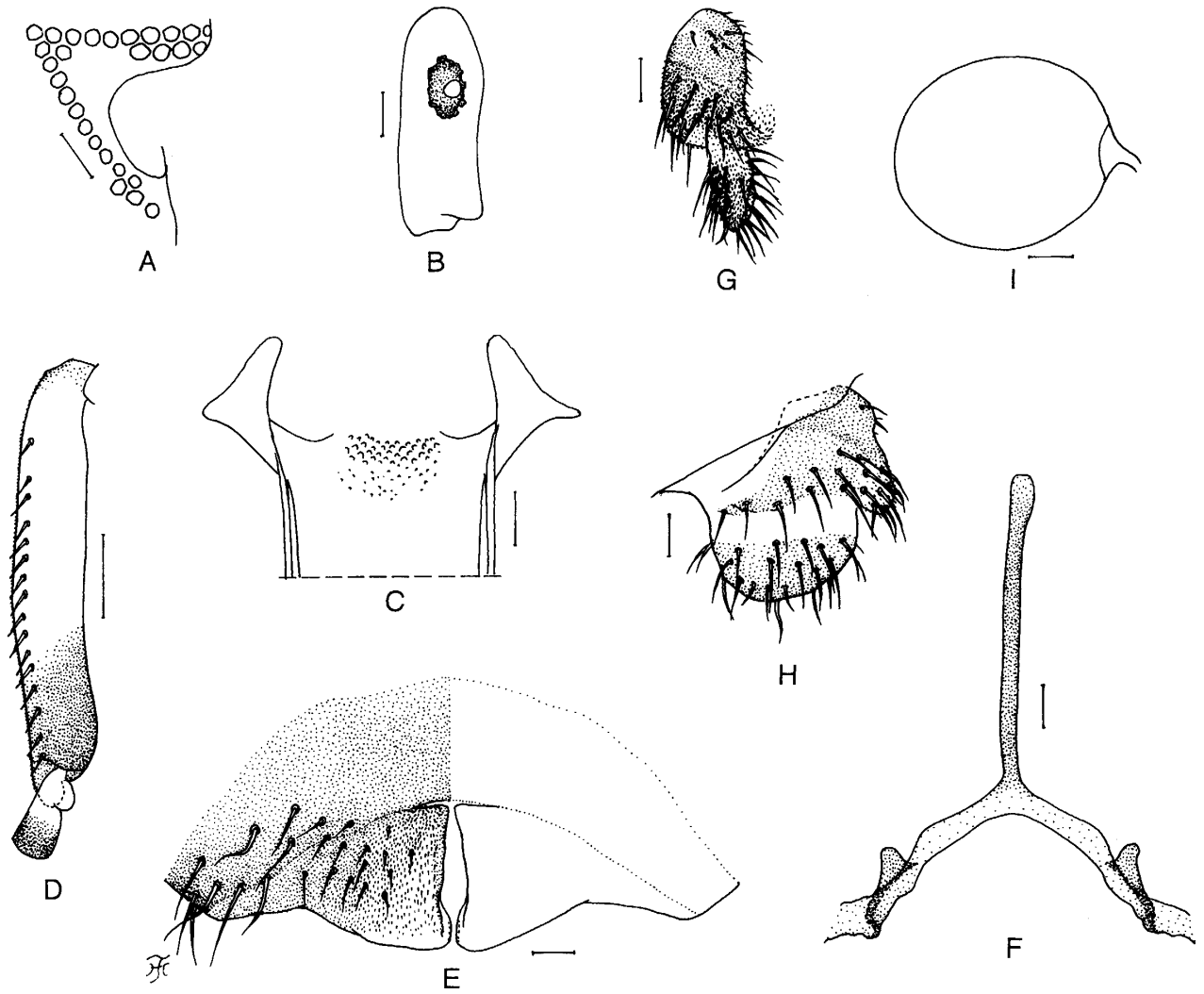

Fig. 4. Adult female of *Simulium* (*Simulium*) *yuphae* sp. nov. A, fronto-ocular area; B, 3rd segment of maxillary palp showing sensory vesicle (right side, front view); C, cibarium; D, basitarsus and 2nd tarsal segment of hind leg (left side, outer view); E, 8th sternite and ovipositor valves *in situ* (ventral view); F, genital fork (ventral view); G and H, paraprocts and cerci on right side (G, ventral view; H, outer view); I, spermatheca. Scale bars. 0.1 mm for D; 0.04 mm for A; 0.02 mm for B, C and E–I.

brown except basal 2/3 of basitarsus and basal 1/2 of 2nd segment yellowish-white; basitarsus (Fig. 4D) parallel-sided, 5.8 times as long as its width, 0.70 and 0.64 times as wide as greatest widths of hind tibia and femur, respectively; calcipala short, slightly shorter than its width at base, and 0.43 times as long as width of basitarsus; pedisulcus distinct. All tarsal claws simple, without subbasal or basal tooth. ***Wing***. Length 2.0–2.2 mm; costa with spinules and hairs; subcosta haired except apical 1/3 or more bare; basal section of vein R bare; hair tuft on stem vein dark brown; basal cell absent. ***Abdomen***. Basal scale brownish-black with fringe of dark hairs. Dorsal surface of abdomen blackish-brown to black, with dark hairs; segment 2 with broad silvery iridescent transverse band; tergites 6–8 shiny. Ventral surface of abdomen brownish-black; segment 7 with pair of weakly developed sternal plates. ***Genitalia***. Sternite 8 (Fig. 3E) well sclerotized, bare medially but with 8 or 9 dark medium-long stout hairs as well as 1–4 pale short slender hairs laterally on each side; ovipositor valves (Fig. 4E) triangular in shape, rounded ventrally, membranous, covered with 7–14 short slender hairs as well as numerous microsetae except narrow portion on posteromedian corner bare; inner margins slightly sinuous, narrowly sclerotized, folded dorsally near apex, and narrowly or moderately separated medially from each other. Genital fork (Fig. 4F) of inverted-Y form, with well sclerotized stem; arms of moderate width, each with strongly

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sclerotized projection directed anterodorsally. Paraproct in ventral view (Fig. 4G) much longer than wide, with anterior 1/2 of ventral surface strongly sclerotized, nearly bare except several short setae and sparse microsetae; paraproct in lateral view (Fig. 4H) somewhat protruding ventrally beyond cercus, with ventral margin slightly concave medially, and covered with 17 or 18 short and medium-long hairs. Cercus in lateral view (Fig. 4H) rounded posteriorly, 0.58 times as long as its greatest width, moderately covered with short and medium-long hairs. Spermatheca (Fig. 4I) nearly ovoid, well sclerotized except small area around juncture with duct unsclerotized, with no definite reticulate surface pattern, with minute internal setae; accessory ducts subequal in thickness to each other and slightly thicker than major duct.

Male. Body length 2.3–2.5 mm. ***Head.*** Width slightly wider than thorax. Upper eye consisting of large facets in 19 or 20 horizontal rows and in 17 or 18 vertical columns. Clypeus black, silvery iridescent when illuminated, sparsely covered with dark long stout hairs along lateral and lower margins. Antenna composed of 2+9 segments, dark brown except scape and pedicel dark yellow to medium brown in dorsal or posterior view (though yellow in ventral or anterior view), and base of 1st flagellar segment yellow; 1st flagellar segment elongate, 1.7–1.8 times as long as 2nd flagellar segment. Maxillary palp composed of 5 segments with proportional lengths of 3rd, 4th, and 5th segments 1.0 : 1.2–1.3 : 2.7–2.8; 3rd segment (Fig. 5A) of normal size; sensory vesicle small, 0.21–0.24 times as long as 3rd segment, globose or ellipsoidal, with small opening. ***Thorax***. Scutum black, with white pruinose pattern composed of anterior pair of triangular spots with rounded apex on shoulders extending posteriorly along lateral margins up to base of wing and large transverse spot entirely covering prescutellar area which is not contiguous to anterior spots; these pruinose areas silvery iridescent when illuminated at certain angles of light; scutum uniformly covered with dark brown recumbent short hairs (in lights these hairs appear bright coppery) interspersed with dark long upright hairs on prescutellar area. Scutellum brownish-black to black, shiny, white pruinose, with several dark upright dark hairs. Postnotum brownish-black to black, shiny, white pruinose, without hairs. Pleural membrane and katepisternum as in female. ***Legs***. Foreleg: coxa whitish-yellow; trochanter light to medium brown; femur medium to dark brown; tibia medium brown to brownish-black with outer portion (except apical tip) largely pale white and white sheeny when illuminated; tarsus brownish-black to black, with short dorsal hair crest; basitarsus dilated, 4.2–4.5 times as long as its greatest width. Midleg: coxa brownish-black; trochanter dark brown; femur dark brown to brownish-black; tibia dark brown to brownish-black though minute base appearing yellowish-white; tibia white sheeny on posterior surface along basal 1/3 of shaft when illuminated; basitarsus whitish-yellow except apical tip medium brown; rest of tarsal segment medium brown except basal 1/2 to 2/3 of 2nd segment whitish-yellow. Hind leg: coxa brownish-black; trochanter dark yellow to light brown; femur dark brown with apical cap brownish-black and minute base light brown; tibia brownish-black with minute base whitish-yellow; tarsus brownish-black except basal 1/2 or a little less of basitarsus and basal 1/2 of 2nd segment yellowish-white; hind basitarsus (Fig. 5B) much enlarged, wedge-shaped, widening from base to a little beyond basal 1/2, then nearly parallel-sided, and slightly narrowed apically; basitarsus 3.8–3.9 times as long as its greatest width, 0.89–0.91 times and 0.86–0.95 times as wide as greatest widths of hind tibia and femur, respectively; calcipala (Fig. 5B) small, as long as, or slightly shorter than, its width at base, and 0.21–0.26 times as wide as greatest width of basitarsus; pedisulcus well marked on 2nd tarsal segment. ***Wing***. Length 2.0 mm; other characters as in female except subcosta bare. ***Abdomen***. Basal scale black with dark long hairs. Dorsal surface of abdomen brownish-black to black, with dark hairs; segments 2, 6 and 7 each with pair of silvery iridescent areas dorsolaterally, those on segment 2 connected broadly to each other in middle. ***Genitalia***. Coxite in ventral view (Fig. 5C) nearly quadrate and in ventrolateral view (Fig. 5D) much shorter than wide. Style elongate in ventral view (Fig. 5C) longer than coxite, gradually narrowed from base to apical 1/3, then nearly parallel-sided up to apex though gently curved inward, with round apex having terminal spine; style in ventrolateral view (Fig. 5D) only slightly narrowed from basal 1/3 toward apex; style in medial and

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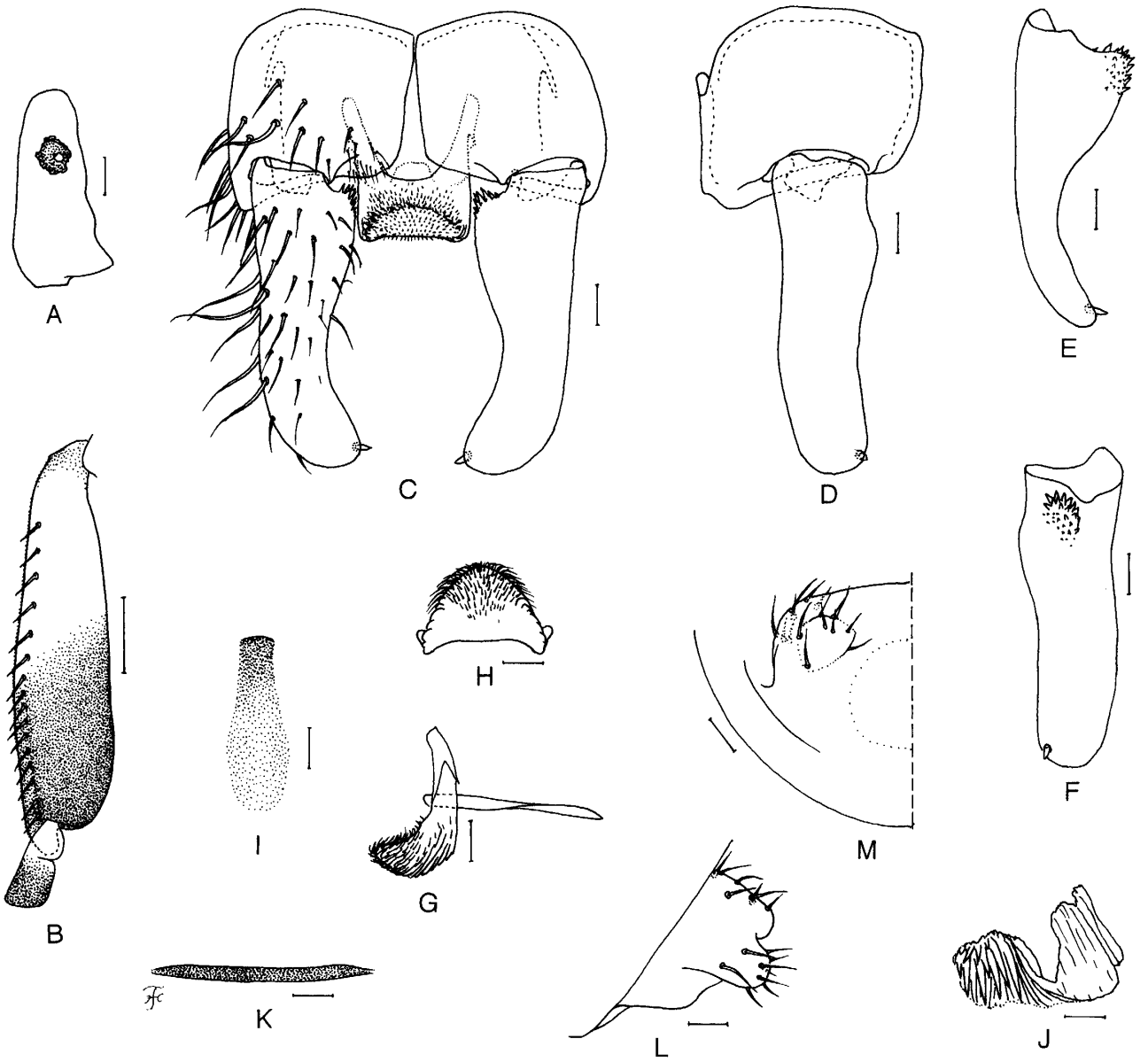

Fig. 5. Adult male of *Simulium* (*Simulium*) *yuphae* sp. nov. A, 3rd segment of maxillary palp with sensory vesicle (right side, front view); B, basitarsus and 2nd tarsal segment of hind leg (left side, outer view); C, coxites, styles and ventral plate *in situ* (ventral view); D, coxite and style (right side, ventrolateral view); E and F, right styles with basal protuberance (E, medial view; F, dorsal view); G, ventral plate and median sclerite (lateral view); H, ventral plate (end view); I, median sclerite (end view); J, paramere (left side, end view); K, dorsal plate; L and M, 10th abdominal segments with cercus on right side (L, lateral view; M, end view). Scale bars. 0.1 mm for B; 0.02 mm for A and C–M.

dorsal views (Fig. 5E, F) with basal protuberance directed dorsomedially, bearing many spinules on its surface. Ventral plate in ventral view (Fig. 5C) with base nearly quadrate in shape, having ventrally-produced hairy process with posterior margin nearly straight and basal arms slightly diverging from each other; ventral plate in lateral view (Fig. 5G) with distinct serrated posterior margin; ventral plate in end view (Fig. 5H) with round hairy process produced ventrally. Median sclerite (Fig. 5I) well sclerotized, plate-like, widening toward middle, then nearly parallel-sided. Paramere (Fig. 5J) with 5 or 6 long hooks as well as a few short ones. Aedeagal membrane moderately covered with minute spines, with well sclerotized dorsal plate (Fig. 5K). Abdominal segment 10 (Fig. 5L, M) with 6 or 7 hairs on each posterolateral corner, of which 3 or 4 hairs on lateral surface, and 2 or 3 hairs on ventral surface. Cercus (Fig. 5 L, M) small, rounded, with 6–8 hairs.

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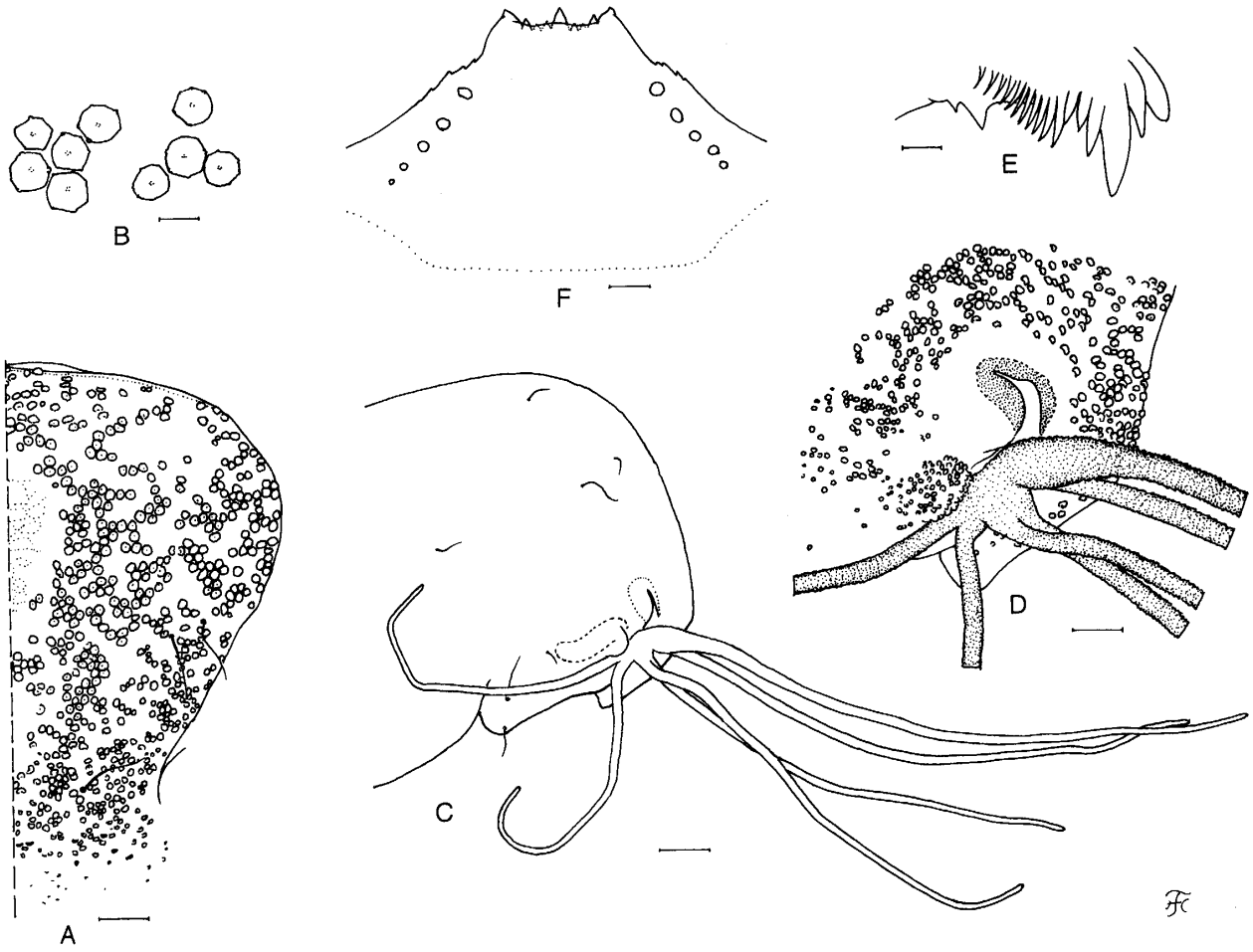

Fig. 6. Pupa and mature larva of *Simulium* (*Simulium*) *yuphae* sp. nov. A–D, pupa and E and F, mature larva. A, head integument showing frontal and facial trichomes and tubercles (left half, front view); B, tubercles with minute secondary projections; C, anterior half of thoracic integument with gill filaments (right side, outer view); D, enlargement of basal portion of gill filaments and surrounding integument showing pit-like organ (right side, outer view); E, apical portion of mandible; F, hypostomium. Scale bars. 0.1 mm for C; 0.05 mm for A and D; 0.02 mm for F; 0.01 mm for B and E.

Pupa. Body length (excluding gill filaments) 2.3–2.6 mm. ***Head***. Integument yellowish-brown, moderately covered with rather large rounded tubercles with a few to several minute secondary projections on frons (Fig. 6A, B), as well as small to medium-sized tubercles without secondary projection, especially on lower portion of frons and antennal sheaths, with 2 frontal and 1 facial pairs of simple slender medium-long trichomes (Fig. 6A); frontal trichomes nearly as long as, or slightly shorter than, facial ones. ***Thorax***. Integument yellowish-brown, moderately covered with rather large rounded tubercles as well as small to medium-sized tubercles on anterior 1/2 except anterolateral small portion with pit-like organ dorsal to gill base bare, and moderately covered with smaller conical tubercles on posterior 1/2; pit-like organ with strongly sclerotized round rim, slightly depressed in center (Fig. 6C, D); thorax on each side with 1 mediodorsal, 2 anterodorsal, 1 mediolateral, and 3 ventrolateral medium-long or short simple trichomes (Fig. 6C). Gill (Fig. 6C, D) with 6 slender thread-like filaments arranged in 3 sessile (or very short-stalked) pairs; filaments decreasing in length from dorsal to ventral, with outer filament of dorsal pair longest of all (ca. 1.3 mm), and 2 filaments of ventral pair shortest (ca. 0.7 mm); outer filament of dorsal pair enlarged at base, and much thicker than its counter inner filament, which is slightly thicker than, or nearly as thick as, 2 filaments of middle pair, which are slightly thicker than, or as thick as, 2 filaments of ventral pair; all filaments slightly tapered toward apex, directed forward except 1 of ventral pair always directed backward, and its counter filament often directed downward

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or backward (though rarely forward) (it is probably due to the fixed direction of very short stalk of ventral pair which is always directed downward); all filaments dark brown, with well marked annular ridges and furrows throughout their length forming reticulate surface patterns, and densely covered with minute tubercles. ***Abdomen***. Dorsally, segment 1 pale yellowish with 1 simple slender medium-long seta on each side; segment 2 nearly transparent, with 1 medium-long simple seta and 5 short simple spinous setae on each side; segments 3 and 4 each with 4 hooked spines along posterior margin and 1 short spinous seta on each side; segments 7–9 each with spine-combs in transverse row (though those on segments 7 and 9 usually smaller in size and fewer in number than those on segment 8), together with comb-like groups of minute spines on each side; segment 9 without terminal hooks. Ventrally, segment 4 with 1 simple hook (subequal in size to those on segments 6 and 7) and 1 simple short seta submedially on each side; segment 5 with pair of bifid hooks submedially on each side; segments 6 and 7 each with pair of bifid inner and simple outer hooks widely spaced on each side. Grapnel-like hooklets absent. ***Cocoon***. Simple, slipper-shaped, tightly woven, with strong anterior rim, slightly or not extending ventrolaterally; individual threads usually invisible; 2.5–3.0 mm long by 1.0–1.4 mm wide.

Mature larva. Body length 4.8–5.0 mm. Body color greyish-black to greyish-brown. Cephalic apotome usually pale white on anterior 1/2 or a little less or more, yellow to light brown on rest, with medium to dark brown area medially just before posterior margin; head spots essentially positive but somewhat variable in pattern due to difference in relative intensity of darkness of spots against background: in some larvae, mediolongitudinal spots similar in color to background, then usually indistinguishable, mediolateral spots and anterior small one of posterolateral spots medium to dark brown and connected to each other by dark band, posterior one of posterolateral spots always similar in color to background, then usually indistinguishable (Fig. 7A); in other larvae, mediolongitudinal spots as well as mediolateral spots medium to dark brown (Fig. 7B), and in some other larvae, mediolateral spots and mediolongitudinal spots connected to each other by dark band (Fig. 7C). Lateral surface of head capsule light to medium brown except eye-spot region yellowish-white and narrow area along anterior margin and wide anteroventral area whitish-yellow; some spots posterior to eye-spot region merged to background dark color or faintly negative (Fig. 7D). Ventral surface of head capsule whitish-yellow except areas along lateral margins of postgenal cleft and along posterior margin of head capsule widely light to medium brown (Fig. 7E); transverse spot on each side of postgenal cleft faintly or moderately positive. Cervical sclerites composed of 1 narrow stick-like and 1 elliptical pieces fused or not fused to each other on each side, not fused to occiput, moderately separated medially from each other. Antenna composed of 3 segments and apical sensillum, much longer than stem of labral fan; length ratio of segments (from base to tip) 1.0 : 1.1 : 0.7. Labral fan with 38–40 main rays. Mandible (Fig. 6E) with mandibular serrations composed of 2 teeth (1 large, 1 small), large tooth at a right angle or a little more on apical side to inner margin of mandible; supernumerary serrations absent; 1st comb-tooth longer than 2nd tooth which is nearly as long as 3rd one. Hypostomium (Fig. 6F) with 9 anterior teeth, of which median tooth and each corner tooth longer than others; lateral margins moderately serrate apically; 5 or 6 hypostomal bristles diverging posteriorly from lateral border on each side. Postgenal cleft (Fig. 7E) deep, triangular, pointed anteriorly, 3.8–4.5 times as long as postgenal bridge. Thoracic cuticle almost bare. Abdominal cuticle bare except both sides of anal sclerite moderately covered with simple colorless setae. Rectal scales clearly discernible. Rectal organ of 3 lobes, each with 9–13 finger-like secondary lobules. Anal sclerite X-shaped, with broadened anterior arms 0.8–0.9 times as long as posterior ones; 1 or 2 sensilla on basal juncture area and 4–13 sensilla just posterior to posterior arms; accessory sclerite absent. Last abdominal segment lacking ventral papillae. Posterior circlet with ca. 78 rows of hooklets with up to 14 hooklets per row.

TYPE SPECIMENS. Holotype female with its pupal exuvia and cocoon, Site B (1,360 m in altitude), Doi Pui National Park, Chiang Mai province, Thailand, 14. V.2005, by W. Choochote. Paratypes: 3

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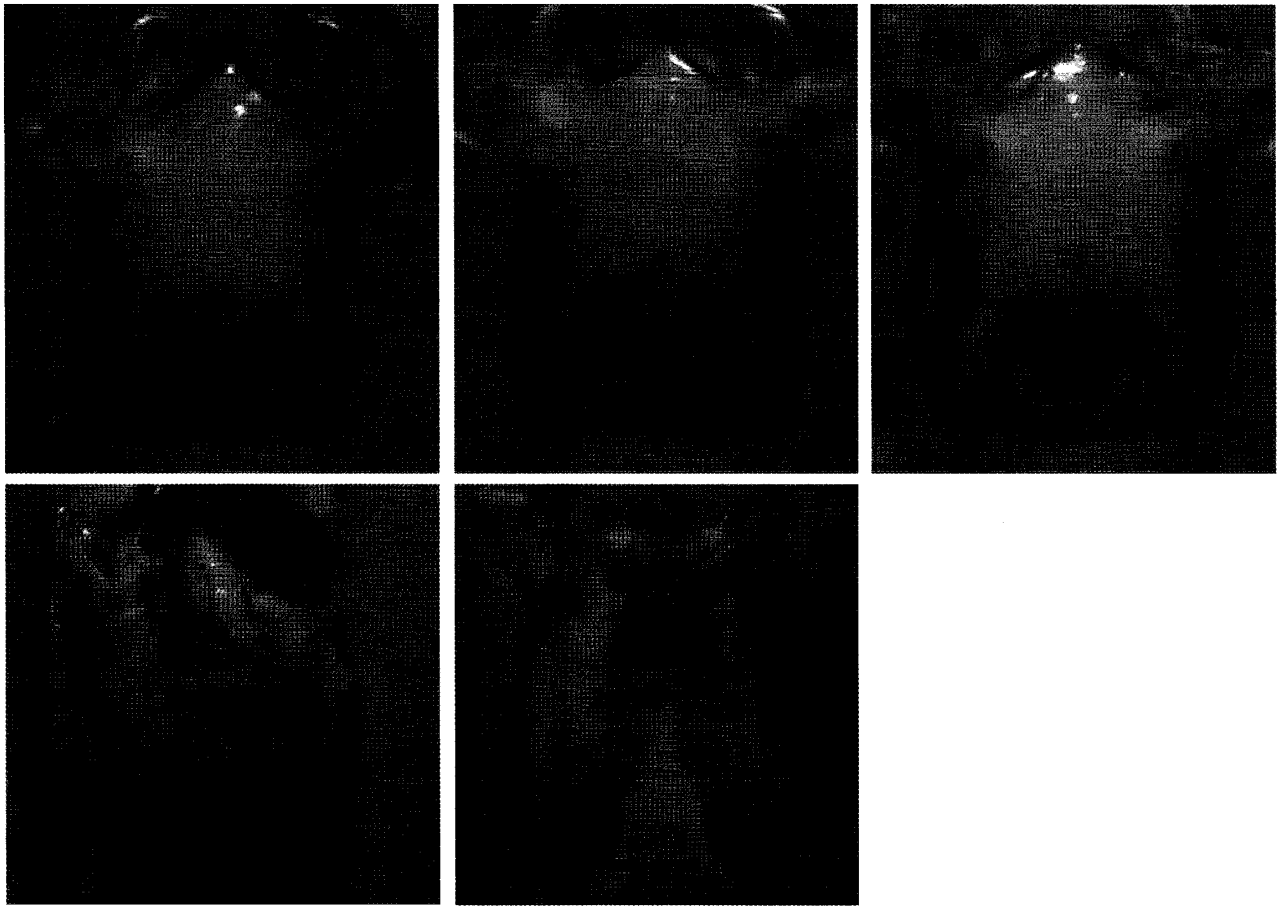

Fig. 7. Head capsules of mature larvae of *Simulium* (*Simulium*) *yuphae* sp. nov. A–C, dorsal view showing different patterns on cephalic apotome; D, lateral view; E, ventral view showing triangular postgenal cleft.

females, 5 males (all reared from pupae), and 3 mature larvae, same data as those of holotype; 3 females, 2 males, Site A (1,420 m in altitude), Doi Pui National Park, 21.V. 2005, by W. Choochote; 3 females, 2 males, Site A (same as above), 21.VI.2005; 18 mature larvae, Site A (same as above), 16. IX.2004, by W. Choochote; 1 female, 4 males, Siribhume Waterfall (1,360 m in altitude), Doi Inthanon National Park, Chiang Mai province, 26.IV.2005, by W. Choochote; 1 female, 1 male, 5 pupae, Sai Yoi Waterfall (830 m in altitude), Chiang Mai province, 19.XII.2002, by W. Choochote.

ECOLOGICAL NOTES. The pupae and larvae of this new species were collected on trailing grasses and dead leaves in small to medium-sized streams running in mountainous areas. Water temperatures measured ranged 16–26℃.

DISTRIBUTION. Thailand.

ETYMOLOGY. The species name *yuphae* is in honor of Dr. Yupha Rongsriyam, former Head, Department of Medical Entomology, Faculty of Tropical Medicine, Mahidol University, from whom WC learned much during his M. Sc. course at Mahidol University.

REMARKS. This new species, assigned to the *tuberosum* species-group redefined by Takaoka and Davies (1996), is very similar to *S.* (*S.*) *brevipar*, which was originally described from Peninsular Malaysia (Takaoka and Davies, 1995) and it is difficult to separate it from the latter. The only clear difference is seen in the configuration of the pupal gill filaments, i.e., one

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of the ventral paired filaments is always directed posteriorly (Fig. 6C) in this new species but directed forward together with the remaining five filaments in *S.* (*S.*) *brevipar*. The other differences, though quantitative, include the height ratio of the female frons to its narrowest width (1.41–1.54 in this new species vs. 1.35 in *S.* (*S.*) *brevipar*), the number of horizontal rows of large upper eye facets (19 or 20 vs. 18), the length ratio of the first flagellar segment of the male antenna to the second one (1.7–1.8 vs. 2.0), the length ratio of the male hind basitarsus to its greatest width (3.8–3.9 vs. 3.5), and the length ratio of larval antennal segments (from base to tip)(1.0 : 1.1 : 0.7 vs. 1.00 : 0.77 : 0.50).

It is noted that the previous distribution record of *S.* (*S.*) *brevipar* from northern Thailand based on the one pupa and one mature larva collected in Doi Suthep, Chiang Mai province, by Takaoka and Saito (1996) should be corrected because the pupal specimen examined was *S.* (*S.*) *yuphae*. So far, no sufficient data are available to delimit the geographical distribution of *S.* (*S.*) *yuphae*. Furthermore, it will be needed to investigate whether *S.* (*S.*) *brevipar* is distributed in Thailand or not.

Acknowledgements

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References

Crosskey, R. W. and Howard, T. M. 1997. A New Taxonomic and Geographical Inventory of World Blackflies (Diptera: Simuliidae). 144 pp., The Natural History Museum, London.

Edwards, F. W. 1934. The Simuliidae (Diptera) of Java and Sumatra. *Arch. f. Hydrobiol.* 13, Suppl. "Tropische Binnengewässer" 5: 92–138.

Takaoka, H. 2001. *Simulium weji* sp. nov. (Diptera: Simuliidae) from Thailand. *Jpn. J. Trop. Med. Hyg.*, 29: 349–354.

Takaoka, H. 2003. The Black Flies (Diptera: Simuliidae) of Sulawesi, Maluku and Irian Jaya. xxii+581 pp., Kyushu University Press, Fukuoka.

Takaoka, H. and Choochote, W. 2002. Taxonomic notes on the *griseifrons* species-group in *Simulium* (*Simulium*) (Diptera: Simuliidae) from Thailand: Descriptions of two new species and description of the male, pupa and larva of *S.* (*S.*) *digrammicum* Edwards. *Jpn. J. Trop. Med. Hyg.*, 30: 115–132.

Takaoka, H. and Choochote, W. 2004a. Two new species of *Simulium* (*Simulium*) (Diptera: Simuliidae) from Thailand. *Trop. Med. Health*, 32: 31–36.

Takaoka, H. and Choochote, W. 2004b. Taxonomic notes on the *griseifrons* species-group of *Simulium* (*Simulium*) (Diptera: Simuliidae) in Northern Thailand. *Trop. Med. Health*, 32: 311–327.

Takaoka, H. and Choochote, W. 2005a. A new species of *Simulium* (*Simulium*) (Diptera: Simuliidae) from Thailand. *Med. Entomol. Zool.*, 56: 43–47.

Takaoka, H. and Choochote, W. 2005b. Two new species of *Simulium* (*Simulium*) (Diptera: Simuliidae) from northern Thailand. *Med. Entomol. Zool.*, 56: 99–110.

Takaoka, H. and Choochote, W. 2005c. Two new species of *Simulium* Latreille (Diptera: Simuliidae) from northwestern Thailand. *Med. Entomol. Zool.*, 56: 123–133.

Takaoka, H. and Choochote, W. 2005d. A new species of *Simulium* (*Simulium*) (Diptera: Simuliidae) from northern Thailand. *Trop. Med. Health*, 33: 95–101.

Takaoka, H. and Choochote, W. 2005e. Two new species of the *griseifrons* species-group of *Simulium* (*Simulium*) (Diptera: Simuliidae) in northern Thailand. *Med. Entomol. Zool.*, 56: 219–235.

Takaoka, H. and Davies D. M. 1995. The Black Flies (Diptera: Simuliidae) of West Malaysia. viii+175 pp., Kyushu University Press, Fukuoka.

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The Japan Society of Medical Entomology and Zoology

Takaoka, H. and Davies D. M. 1996. The Black Flies (Diptera: Simuliidae) of Java, Indonesia. viii+81 pp., Bishop Mus, Bull. Entomol. 6, Bishop Museum Press, Hawaii.

Takaoka, H. and Kuvangkadilok, C. 1999. Four new species of black flies (Diptera: Simuliidae) from Thailand. *Jpn. J. Trop. Med. Hyg.*, 27: 497–509.

Takaoka, H. and Saito, K. 1996. A new species and new records of black flies (Diptera: Simuliidae) from Thailand. *Jpn. J. Trop. Med. Hyg.*, 24: 163–169.

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